United States
Department of
Agriculture

Forest Service

**Intermountain
Research Station
Ogden, UT 84401**

General Technical
Report INT-199

February 1986

Fire Danger Computations with the Hewlett-Packard HP-71B Calculator

**Robert E. Burgan
Ronald A. Susott**

THE AUTHORS

ROBERT E. BURGAN received his bachelor's degree in forest engineering in 1963 and his master's degree in forest fire control in 1966 from the University of Montana. From 1963 to 1969, he served on the timber management staff of the Union and Bear-Sleds Districts, Wallowa-Whitman National Forest. From 1969 to 1975, he was a research forester on the staff of the Institute of Pacific Islands Forestry, Honolulu, HI. He transferred to the National Fire-Danger Rating research work unit at the Northern Forest Fire Laboratory (now the Intermountain Fire Sciences Laboratory), Missoula, MT, in 1975. Since 1979 he has been a research forester in the Fire Behavior: Fundamentals and Systems Development research work unit at the lab.

RONALD A. SUSOTT is a research chemist at the Intermountain Fire Sciences Laboratory in Missoula, MT. He received his B.S. degree in 1966 and a Ph.D. degree in chemistry from the University of Montana in 1970. He held a research associate position at the Wood Chemistry Laboratory of the University of Montana from 1970 to 1974. He also held the position of chemist in the thermal analysis laboratory at Columbia Scientific Industries from 1974 to 1976. He joined the Fire Fundamentals research work unit of the Intermountain Research Station's Intermountain Fire Sciences Laboratory in 1976, specializing in the thermal properties of forest fuels. Since 1979 he has been part of the Fire Behavior: Fundamentals and Systems Development research work unit at the lab.

RESEARCH SUMMARY

A fire danger Custom Read Only Memory (CROM) has been developed for the Hewlett-Packard model 71B handheld calculator. This calculator replaces the Texas Instruments TI-59 and can be used in either office or field situations to compute the 1978 National Fire-Danger Rating (NFDR) indexes and components. A separate CROM was developed and a user's manual is being written for calculating several variables to estimate wildfire behavior (Susott and Burgan 1986).

The program reported on here can perform NFDR calculations in two modes: (1) compute NFDR indexes and components from standard NFDRS weather observations, and (2) compute NFDR indexes and components using direct entry of the input data.

Fire Danger Computations with the Hewlett-Packard HP-71B Calculator

Robert E. Burgan
Ronald A. Susott

INTRODUCTION

The Hewlett-Packard HP-71B has been selected to replace the Texas Instruments TI-59 (Burgan 1979) for field computations of fire danger and fire behavior. For the TI-59, both fire danger and fire behavior computations were implemented in a single Custom Read Only Memory (CROM). These programs, and their associated users' manuals, have been separated for the HP-71B. This manual describes use of the HP-71B to calculate indexes and components of the 1978 National Fire-Danger Rating (NFDR) System (Deeming and others 1977). Operation of a separate program written for field-oriented fire behavior applications will be described in a companion publication, "Fire Behavior Computations with the Hewlett-Packard HP-71B Calculator" (Susott and Burgan 1986). Each program is available as a separate Custom Read Only Memory.

Separate self-study guides have been prepared for the fire danger and fire behavior programs. These are available through agency coordinators who will distribute the guides and help answer questions about the calculator and course material.

CALCULATOR FEATURES

The HP-71B has several features that make it more suitable for field use than the TI-59 it replaces:

- A liquid crystal display (LCD) that is easy to read in daylight.
- The capability to display both alphabetic and numeric characters. Requests for input and displayed output can now be appropriately labeled, thus eliminating the need for keyboard overlays.
- Use of complementary metal oxide semiconductor (CMOS) architecture which, because of its very low power requirement, permits many hours of operation between battery changes.
- Use of replaceable rather than rechargeable batteries.
- A continuous memory that retains the information stored in the calculator even when the calculator is turned off.
- A capability to operate with optional battery-operated printers, data cassettes, and disk drives.
- A powerful BASIC programming language that is available for many other user applications.

PROGRAM FEATURES

The 1978 NFDR program implemented on the HP-71B performs the same calculations as the TI-59 NFDR program. That is, no changes have been made in the computational algorithms. Highlights of the HP-71B program are:

- NFDR indexes and components can be calculated from either weather data recorded at basic observation time (WEATHER option) or from direct entry of fuel moistures and limited station data (DIRECT option).
- The current 20 NFDR fuel models are included in the CROM, so no fuel model cards are necessary.
- Up to five user-defined fuel models can be stored. Such models may be either a modification of an existing NFDR fuel model or may be developed from entirely new data. Caution is strongly advised in the use of this feature. There is **no** fuel modeling system available for analyzing NFDR fuel models. The fuel modeling subsystem of BEHAVE (Burgan and Rothermel 1984) **cannot** be used to build NFDR fuel models. Without proper analysis, misleading fuel models can easily be built. This feature is primarily for use in fire planning by those trained in fuel modeling.
- Although the program defines a specific sequence for entering data and obtaining calculated results, if inappropriate for your use, both the input and output sequences can be reordered. Specific instructions for reordering sequences can be obtained from: NFDR Liaison, Boise Interagency Fire Center, 3905 Vista Avenue, Boise, ID 83705.
- An automatic update capability is available for those daily inputs whose values must be carried forward. The continuous memory of the HP-71B will retain these and other values even when the calculator is turned off. The automatic update feature may easily be switched on and off.
- The program checks neither the completeness nor the correctness of the inputs. But the program will not accept values outside a reasonable range assigned each input item. Users must be certain that inputs are correct before computing the NFDR indexes and components. If there is any question about this, inputs should be listed before the program is run. The inputs and outputs are stored in continuous memory, so there will always be some value—good or bad—assigned to the inputs.

• All critical values from the most recent run are automatically saved in a file called DSTATE. (Other files used by this program—NFDR, MODELS, NAMES—are in the fire danger custom module.) The DSTATE file is updated after each run in DIRECT and WEATHER, after a fuel model is "saved," and when you "quit" the NFDR program completely. These values are read back in from the DSTATE file at the beginning of each run. This eliminates the possibility of any NFDR data being altered if the HP-71B is used for either manual calculations or another program application. Operation of the NFDR program will not alter any values assigned to variables created in other programs and saved in continuous memory. Some global flags and default values are changed during operation, including flags 0 through 8, DELAY 0, 0, OPTION ROUND NEAR, OPTION BASE 1, OPTION ANGLE RADIANS, and display format STD. Refer to the HP-71 Reference Manual for more information about these values.

• The 1,000-hour timelag fuel moisture (1000 HRFM) calculation is the same as used for the TI-59. To enhance user convenience, it differs slightly from the calculations done by AFFIRMS (Helfman and others 1980).

• Relative humidity is required rather than dewpoint or dry bulb and wet bulb temperatures.

• Fuel-stick moisture adjustments for aging must be done before using the NFDR program.

PROGRAM STRUCTURE

The NFDR program structure consists of a MAIN section that contains three modules—MODEL, DIRECT, and WEATHER—and two primary commands—PRINTER and QUIT. Several second-level keyword commands are available within each of the three modules (appendix A). Control of program operation is through the use of one-letter keywords to select a module or perform one of the keyword commands. These are the underlined letters in appendix A. Once a module is selected, its keywords are operative and will appear in the display. You can switch from one module to another only by going through the MAIN section. For example, if you were using the DIRECT module and wanted to go to the WEATHER module, you would have to Quit DIRECT, thus getting back to the MAIN section, from which you could select the WEATHER module. The Printer keyword will alternately direct I/O to the printer or to the display when used repeatedly. If a printer is not attached to the calculator or is attached but not turned on, use of this keyword will only result in display of the message "NO PRINTER AVAILABLE". The NFDR program should always be ended by entering Q for Quit while in the MAIN section to properly save your current data and return the calculator to normal use.

OPERATION OF THE "MAIN" SECTION

After the HP-71B has been turned on, the NFDR program can be started in either of two ways:

1. Type in RUN NFDR and press the ENDLINE key. This will always work even if the program has been paused.
2. If the NFDR program was the last program run before the calculator was turned off, just press the RUN key.

When the program starts running, PRGM will appear in small letters on the right side of the display. This is followed immediately by a short display of the words "FIRE DANGER". The program then searches to determine whether or not a printer is attached to the calculator. If a printer is attached **and turned** on, the message "PRINTER ON" is briefly displayed; otherwise the message "NO PRINTER AVAILABLE" is briefly displayed. Finally, the program indicates you are in the MAIN section by displaying the module and keyword message "MAIN: M,D,W,P,Q?" At this point, you can go to one of the modules—Model, Direct, or Weather, toggle the Printer or Quit by entering the appropriate letter in the display, and pressing ENDLINE. If you press any other letter, a number or a symbol, and ENDLINE, the incorrect entry will just disappear and you can try again.

Operation of the fire danger program uses some of the HP-71B memory. Large user files or previously defined variables can cause the "Insufficient Memory" error at unpredictable locations in the program. The "DESTROY ALL" statement may reclaim enough memory to run the program, or files can be removed with the "PURGE" statement. Users who frequently have large files in memory should consider obtaining the optional memory expansions available for the HP-71B.

Erroneous entries can be corrected before the ENDLINE key is pressed by:

1. Holding down the gold f key and either pressing the < key repeatedly or else holding the < key down. This invokes the "BACK" command printed in gold letters on the calculator.
2. Pressing or holding the < key to back up the cursor, then deleting the unwanted characters by pressing or holding the f key and then the > key. This invokes the "−CHAR" command.
3. Using the < key to back up the cursor, then typing in the correct inputs. If extra characters remain, they can be deleted individually by pressing the f and > keys, or all at once ("−LINE" command) by pressing the f and ∨ keys.

Refer to the HP-71B User's Manual for more detailed line-editing instructions.

Normal termination of the NFDR program is with use of the keyword Quit when you are in the MAIN section. This ensures that current program variables are saved. Although it is not recommended, you may turn the calculator off any time the program waits for user input, by pressing f ON to invoke the "OFF" command. The calculator will also automatically turn off if there is no user activity for 10 minutes. In these cases, when the calculator is turned back on, the SUSP annunciator will appear in the display, indicating program operation is now suspended. To continue from this point, press f +

for the "CONT" or continue command, and a question mark "?" will appear. The calculator is now waiting for you to input the value for the item being requested when the calculator was turned off. If you don't know what to enter, press the + (plus sign), ENDLINE and the display will then show the input being requested when the calculator was turned off. Check your inputs and correct any erroneous values before continuing. Turning the calculator off while it is doing calculations may result in loss of data and leave some calculator keys inoperable. If this happens, enter "RUN NFDR" and Quit when the display reads "MAIN: M,D,W,P,Q?". Then the calculator keys will operate normally again.

INPUT AND OUTPUT PROCEDURES

Definition of Inputs

The following tabulation defines the inputs and provides instructions concerning values used in operating the WEATHER module.

All three modules—MODEL, DIRECT, and WEATHER—employ the same techniques for data entry and modification.

The inputs and outputs for each module have been numbered and arranged in a specific sequence. If you modify the order of the input/output lists of appendix B, the line numbers will still be sequential (1,2,3,...), but different input and/or output items will be associated with them. The item numbers provide much flexibility in data entry, listing, and output of results.

Entry	Mnemonic	Item	Instructions
1	UPDATE	Auto updating	No for first day, then Yes
2	MONTH	Month of year	Enter as a whole number
3	DAY	Day of month	Enter as a whole number
4	GREEN DAYS	Green days	Prior to greening or after a freeze use 0. Enter 1 on the day green-up begins, 2 on the second day of green-up, 3 on the third, and so on. Continue entering successively higher numbers until both herbaceous and woody vegetation go dormant as a result of a freeze, drought, or seasonal cycle; then use 0 again.
5	STATE WTHR	State of the weather	Enter as whole number 0-9
6	TEMP	Dry bulb temperature	Enter in degrees fahrenheit
7	RH	Relative humidity	Enter directly. Cannot be calculated from wet bulb temperature.
8	10 HRFM	Observed fuel sticks	If not known, enter 2 to obtain a calculated value.
9	WINDSPEED	20-foot windspeed	Enter in miles per hour
10	MAX TEMP	Maximum temperature	Enter in degrees fahrenheit
11	MIN TEMP	Minimum temperature	Enter in degrees fahrenheit
12	MAX RH	Maximum relative humidity	Enter in percent
13	MIN RH	Minimum relative humidity	Enter in percent
14	PRECIP DUR	Precipitation duration	Enter to nearest whole hour
15	Y-100 HRFM	Yesterday's 100-hour moisture	For the first day's calculations use 10, 15, 20, or 25 for climate classes 1, 2, 3, or 4, respectively.
16	Y-1000 HRFM	Yesterday's 1,000-hour moisture	For the first day's calculations use 15, 20, 25, or 30 for climate classes 1, 2, 3, or 4, respectively.
17	Y-X1000 HRFM	Yesterday's X1,000 moisture	For the first day's calculations use the value for Y-1000 HRFM as described above.
18	Y-HERB FM	Yesterday's herb moisture	For the first day's calculations use your best estimate.
19	MAN RISK	Man-caused risk	Determine as instructed in the National Fire-Danger Rating System—1978 (Deeming and others 1977) and enter the value for today.
20	LGT ACT LVL	Lightning activity level	Determine as instructed in the National Fire-Danger Rating System—1978 (Deeming and others 1977) and enter the value for today.
21	Y-LGT OCC	Yesterday's lightning occurrence	For the first day's calculations use 0
22	FUEL MODEL	Fuel model name	Enter letter for appropriate model
23	LATITUDE	Station latitude	Enter to nearest whole degree
24	SLOPE CLASS	Slope class	Enter slope class assigned to station
25	CLIM CLASS	Climate class	Enter climate class assigned to station
26	LRSF	Lightning risk scaling factor	Enter value assigned to station

The inputs are limited to reasonable ranges as listed on the worksheets. If you have not assigned a value to a required input item, the minimum value of the range for that item will automatically be assigned and used.

Entering and Listing Inputs

To enter or list input items, you can

• Begin entering or listing data at the first item in the list by entering I or L, respectively.

• Begin entering or listing data at any item number by entering I# or L#, respectively, where # is the item number. A space between L and # is optional. For example, entering I4 when the display reads WEATHER: I,L,R,Q will allow you to enter green days (fourth item in the weather input list). Entering I4 when the display reads DIRECT: I,L,R,Q will allow entry of 100-hour fuel moisture (fourth item in the DIRECT list).

Once you have started entering input data at some point in the input list, you can continue sequentially from there. Entry of data can be terminated at any time by pressing ENDLINE without first keying in an entry. This will not affect the input parameter whose value is being requested.

Similarly, input listing can be started at any point by entering L#. Subsequent items can be listed by pressing the ∨ key. Previous items can be listed by pressing the ∧ key. Terminate the listing by pressing ENDLINE. When a printer is attached, there is no pause between list items, and all remaining items will be printed.

Changing Inputs

The value of individual input items can be changed by entering I# where # is the number of the input parameter to be changed. The display will show the mneumonic and range for that item number. Enter the value and press ENDLINE. The next input item will then appear in the display, but if you do not want to change its value, press ENDLINE .

Obtaining Outputs

After you are certain the input values are correct, outputs from a DIRECT or WEATHER run may be obtained by:

• Entering R to start at the beginning of the output list.

• Entering R# to start at the location of the item number specified.

If you are not using a printer, you may scroll up or down the output list by repeatedly pressing the ∧ or ∨ keys, respectively. Output listing is terminated by pressing ENDLINE. If the output is going to a printer, the ∧, ∨ and ENDLINE keys are deactivated and the list is printed from your starting point to the end of the list.

In some applications, it may be convenient to avoid computation of the man-caused occurrence index (MCOI) and/or lightning risk (LRISK) and lightning occurrence index (LOI). If man-caused risk (MAN RISK) is entered as zero, the man-caused occurrence index will not be output. If the lightning risk scaling factor (LRSF) is zero, neither lightning activity level (LGT ACT LVL) nor yesterday's lightning occurrence index (Y-LGT OCC) inputs will be requested, nor will LRISK or LOI be output. If both MAN RISK and LRSF are zero, none of the above outputs will be calculated.

MAN RISK is part of the daily input list, so you can always enter a nonzero value. But the LRSF is at the bottom of the input list as part of the station data. It was placed there because it normally does not change, so there is no reason to ask for it daily. So, if the LRSF is set to zero and you want the lightning related outputs, first change it to a nonzero value by entering an LRSF value individually, then begin normal data entry. If LRSF is not zero, LGT ACT LVL and Y-LGT OCC inputs will be requested and LRISK and LOI will be output.

Thus, any of four output lists may be selected in either the DIRECT or WEATHER modules as follows:

• List 1 - a complete list of all eight NFDR indexes and components, obtained by entering valid data for all the inputs

• List 2 - elimination of the man-caused occurrence index (MCOI) by entering zero for man-caused risk (MAN RISK)

• List 3 - elimination of lightning risk (LRISK) and the lightning occurrence index (LOI) by entering zero for the lightning risk scaling factor (LRSF)

• List 4 - elimination of MCOI, LRISK, and LOI by entering zero for both MAN RISK and LRSF

OPERATION OF THE "MODEL" MODULE

The purpose of this module is to permit the modification of an existing NFDR fuel model or the entry of an entirely new one. Because of the difficulty of building reliable fuel models, we suggest user models be built by slightly modifying existing NFDR models rather than developing entirely new models. An example of this is switching herbaceous type between annual and perennial. Fire danger indexes cannot be calculated with this module—it is strictly for modifying and saving user models.

When the calculator display shows - MODEL: G,I,L,S,Q? - you are in the MODEL module and may:

• Get an NFDR model (A-U except M) or an existing user model (V-Z) by entering G and a model letter. For example, if the display shows - MODEL: G,I,L,S,Q? - you can get model B by entering GB and pressing ENDLINE. The display will flash "MODEL B LOADED". If you just enter G, the program will request a model by displaying "FUEL MODEL (A-Z)?".

Because NFDR model M does not exist, an attempt to load it by entering GM will result in another request for the model, as above. If an M is entered at this point, it will just disappear when ENDLINE is pressed, and no model will be loaded. Either enter a valid model letter or just ENDLINE to return to the module prompt.

If you try to Get a user model that does not exist, the calculator will display "MODEL NOT IN FILE", and

request another input. Get will load only user models (V-Z) if they have been filed using a Save command.

• Input all the data for a new model by entering I when the display shows - MODEL: G,I,L,S,Q? The program recognizes that some inputs are not always required. For example, if the WOOD LOAD is entered as zero, the WOOD S/V ratio input will not be requested. HERB TYPE and HERB S/V ratio are similarly linked to HERB LOAD.

• Input individual parameters by referring to their line numbers. For example, I3 will cause the calculator to request a value for 10 HR LOAD, the third item in the model input list. This procedure will allow input of HERB and WOOD S/V ratios and HERB TYPE even if they are not needed. The values assigned to unneeded inputs are saved in the user file DSTATE, but they have no effect on calculations made in DIRECT or WEATHER.

• List the current values from the beginning (by entering L) or from any other location in the list by entering a line number with the L; for example, L3.

• Save a model in the "USERMOD" fuel model file, which the program automatically creates for you.

• Quit the MODEL module.

As mentioned previously, both input and list can be terminated by pressing ENDLINE without first keying in an entry.

If you just Get an NFDR model and try to Save it without giving it another name, you will be asked to name the model (V-Z) because you cannot save a model named A-U. If you attempt to save a model named V-Z and one already exists in the USERMOD file, you will be asked whether or not you want to "KILL OLD MODEL (Y/N)?". This gives you the options of assigning a different name, not saving the model, or saving over an existing fuel model. You can also Save a model by typing S and a model letter (V-Z), then pressing ENDLINE; for example, SV ENDLINE.

When you save a model by entering Save after inputting values for one or more fuel model parameters, the calculator will automatically calculate and display the maximum probable spread rate (SCM) as calculated using the following environmental conditions:

1-hour fuel moisture	4%
10-hour fuel moisture	6%
100-hour fuel moisture	8%
1,000-hour fuel moisture	11%
Herbaceous fuel moisture	65%
Woody fuel moisture	75%
Windspeed (20-ft)	20 mi/h
Slope class	1 (22.5% slope)
Climate class	3

The SCM value is used in calculating the ignition component (IC). Write the SCM value on the fuel model form and press ENDLINE to continue. The entire model will then be stored in the USERMOD file.

Any fuel model you "Get" or build in this module will also be assigned to the DIRECT and WEATHER modules. But both DIRECT and WEATHER also allow you to assign a fuel model. A fuel model assigned in any one of the three modules is automatically assigned to the other two modules.

OPERATION OF THE "WEATHER" MODULE

An update option included in this module provides the choice of whether or not to automatically update those input items whose values must be carried forward from day to day. The updatable items are 100-hour fuel moisture (100 HRFM), 1,000-hour fuel moisture (1000 HRFM), X1,000 moisture (X1000 HRFM), live herbaceous moistures (HERB FM), and the lightning occurrence index (LOI). The "UPDATE" option is available in the WEATHER module only. Selection of UPDATE (Y/N) is the first item in the weather input list.

To establish valid starting values at the beginning of a fire season, set UPDATE to No, enter the first day's weather data (items 2-21), the station data (items 22-26), complete the run, and record the results. Then Input line 1 and change UPDATE to Yes. Daily NFDR runs can then be made by just selecting the WEATHER module, entering the current day's data, and completing the run. You will not be queried for the updatable items unless you change UPDATE to No to permit manual entry.

Input of any WEATHER module input item except the UPDATE input itself (Y or N) or fuel model, will change the values of the updatable items as long as UPDATE is set to Yes. But you can run multiple fuel models with UPDATE set to Yes without altering the values of the updatable items. This is a feature to allow use of the current day's weather to calculate NFDR indexes and components for several fuel models. The same slope and climate class should be associated with these models. If they are not, the weather data is probably not representative, and the fuel moistures may not be appropriate. For models run in this manner, you must be absolutely certain that the live herbaceous fuel load, if present, is designated as either annual (herb type 1) or perennial (herb type 2). Otherwise, you will erroneously use the moisture content calculated for annuals, in the computations for models containing perennials, or vice versa. Model A is the only standard NFDR fuel model designated as having annual herbaceous vegetation; however, you may create user models (V-Z) having either annual or perennial vegetation.

Fire danger computations should begin while the previous year's herbaceous vegetation is still "cured." In this situation, keep entering green days as Ø until greenup starts. Then begin incrementing the green day's value by 1 each day. This will cause the live herbaceous moisture to begin increasing to some maximum value, depending on other daily weather data entered as the season progresses, and then begin decreasing when summer drying begins. As drying continues, the moisture content of "annual" herbaceous vegetation will gradually decrease to 30 percent, at which point it will be considered completely cured and herbaceous fuel moisture will automatically be set equal to the 1 HRFM.

The moisture content of "perennial" herbaceous vegetation will increase and decrease in response to wetting and drying cycles. It will not decrease below 30 percent unless you force it to a "cured" state by entering a

green day's value of Ø. This will cause the value for moisture content of perennial herbaceous vegetation to be set equal to the 1 HRFM.

Example "WEATHER" Runs

Two example weather runs will illustrate:

1. Entering data and obtaining output for the first day of a fire season.

2. Entering data and obtaining output for the second and subsequent days' NFDR calculations.

Select the WEATHER module and Input, then List the data for day 1 in the following tabulation (exhibit 1). Run the program and verify the outputs. Set UPDATE to Yes, enter and list data for day 2, then Run the program, and verify the outputs. Example printer output for these two runs is provided (exhibits 2 and 3).

Exhibit 1.—Example WEATHER module inputs and outputs for 2 days.

SAMPLE NFDR WEATHER OPTION DATA FORM

Name _____ Date _____ Sheet _____ of _____

INPUTS

Line Number	Mnemonic	Item	Range	Value		
1	UPDATE	Update	(Y/N)	N	Y	
2	MONTH	Month	(1-12)	5	5	
3	DAY	Day	(1-31)	29	30	
4	GREEN DAYS	Green days	(0-366)	0	1	
5	STATE WTHR	State of weather	(0-9)	3	3	
6	TEMP	Dry bulb temperature	(0-120°F)	69	54	
7	RH	Relative humidity	(0-100%)	34	66	
8	10 HRFM	[1]10-hour fuel moisture	(2-50%)	10	13	
9	WINDSPEED	20-foot windspeed	(0-60 mi/h)	7	2	
10	MAX TEMP	Maximum temperature	(0-120°F)	71	70	
11	MIN TEMP	Minimum temperature	(0-120°F)	31	43	
12	MAX RH	Maximum relative humidity	(0-100%)	99	99	
13	MIN RH	Minimum relative humidity	(0-100%)	18	50	
14	PRECIP DUR	Precipitation duration	(0-24 hours)	0	1	
15	Y-100 HRFM	Yesterday's 100-hour moisture	(2-50%)	12.29	U[4]	
16	Y-1000 HRFM	Yesterday's 1000-hour moisture	(2-50%)	20.95	U[4]	
17	Y-X1000 HRFM	Yesterday's X1000 moisture	(2-50%)	20.95	U[4]	
18	Y-HERB FM	Yesterday's herb moisture	(2-50%)	7	U[4]	
19	MAN RISK	[2]Man-caused risk	(0-100)	1	15	
20	LGT ACT LVL	Lightning activity level	(1-6)	1	2	
21	Y-LGT OCC	Yesterday's lightning occurrence	(0-100)	1	ENDLINE	
22	FUEL MODEL	Fuel model name	(A-Z)	G		
23	LATITUDE	Latitude	(−67 to 67°)	48		
24	SLOPE CLASS	Slope class	(1-5)	3		
25	CLIM CLASS	Climate class	(1-4)	3		
26	LRSF	[3]Lightning risk scaling factor	(0-1)	1.0		

(con.)

SAMPLE NFDR WEATHER OPTION DATA FORM (Con.)

Name _____ Date _____ Sheet _____ of _____

OUTPUTS

Line Number	Mnemonic	Item	Units	Value		
	Indexes and Components					
1	SC	Spread Component		11	5	
2	ERC	Energy Release Component		28	24	
3	BI	Burning Index		42	28	
4	IC	Ignition Component		21	5	
5	MCOI	[2]Man-Caused Occurrence Index		0	1	
6	LRISK	[3]Lightning Risk		0	13	
7	LOI	[3]Lightning Occurrence Index		0	1	
8	FLI	Fire Load Index		30	20	
	Moistures					
9	1 HRFM	1-hour fuel moisture	(pct)	7.3	12.2	
10	10 HRFM	10-hour fuel moisture	(pct)	10.0	13.0	
11	100 HRFM	100-hour fuel moisture	(pct)	12.29	13.62	
12	1000 HRFM	1000-hour fuel moisture	(pct)	20.57	20.46	
13	X1000 HRFM	X1000 fuel moisture	(pct)	20.57	20.46	
14	WOOD FM	Live woody fuel moisture	(pct)	70	74	
15	HERB FM	Live herbaceous fuel moisture	(pct)	7	20	

[1]If a 10 H moisture is input, that same value will be output, except that it will never be less than 2. If the 10 H moisture is entered as 2, a calculated value will appear in the output list.
[2]If man-caused risk is 0, man-caused occurrence index will not be output.
[3]If the lightning risk scaling factor is 0, lightning risk and lightning occurrence Index will not be output.
If both man-caused risk and lightning risk scaling factor are zero, man-caused occurrence index, lightning risk, and lightning occurrence index will not be output.
[4]Updatable items not requested because UPDATE is set to Yes.

Exhibit 2.—Example printer output—first day.

1	UPDATE	N
2	MONTH	5
3	DAY	29
4	GREEN DAYS	0
5	STATE WTHR	3
6	TEMP	69
7	RH	34
8	10 HRFM	10.0
9	WINDSPEED	7
10	MAX TEMP	71
11	MIN TEMP	31
12	MAX RH	99
13	MIN RH	18
14	PRECIP DUR	0.00
15	Y-100 HRFM	12.29
16	Y-1000 HRFM	20.95
17	Y-X1000 HRFM	20.95
18	Y-HERB FM	7
19	MAN RISK	1
20	LGT ACT LVL	1
21	Y-LGT OCC	1
22	FUEL MODEL	G
23	LATITUDE	48
24	SLOPE CLASS	3
25	CLIM CLASS	3
26	LRSF	1.00

1	SC	11
2	ERC	28
3	BI	42
4	IC	21
5	MCOI	0
6	LRISK	0
7	LOI	0
8	FLI	30
9	1 HRFM	7.3
10	10 HRFM	10.0
11	100 HRFM	12.29
12	1000 HRFM	20.57
13	X1000 HRFM	20.57
14	WOOD FM	70
15	HERB FM	7

Exhibit 3.—Example printer output—second day.

1	UPDATE	Y
2	MONTH	5
3	DAY	30
4	GREEN DAYS	1
5	STATE WTHR	3
6	TEMP	54
7	RH	66
8	10 HRFM	13.0
9	WINDSPEED	2
10	MAX TEMP	70
11	MIN TEMP	43
12	MAX RH	99
13	MIN RH	50
14	PRECIP DUR	1.00
15	Y-100 HRFM	12.29
16	Y-1000 HRFM	20.57
17	Y-X1000 HRFM	20.57
18	Y-HERB FM	7
19	MAN RISK	15
20	LGT ACT LVL	2
21	Y-LGT OCC	0
22	FUEL MODEL	G
23	LATITUDE	48
24	SLOPE CLASS	3
25	CLIM CLASS	3
26	LRSF	1.00

1	SC	5
2	ERC	24
3	BI	28
4	IC	5
5	MCOI	1
6	LRISK	13
7	LOI	1
8	FLI	20
9	1 HRFM	12.2
10	10 HRFM	13.0
11	100 HRFM	13.62
12	1000 HRFM	20.46
13	X1000 HRFM	20.46
14	WOOD FM	74
15	HERB FM	20

In normal daily operation, the calculator will be turned on, the WEATHER module selected, and either I2 or I3 entered to begin inputs at month or day, respectively. Inputs do not have to begin at UPDATE (I1) unless you want to change the UPDATE setting. Multiple fuel models **all** having the same herb type can be run with UPDATE set to Yes by entering I22, fuel model, then pressing ENDLINE and Run. Verify this by entering I22, fuel model C, ENDLINE when latitude is requested, and then Run. Note that the NFDR index and component values changed from the results of the day 2 run, but the moisture outputs did not. Then enter model G again (I22, G), press ENDLINE to terminate inputs, and do another run. **All** the outputs will exactly match the day 2 run. This illustrates the procedure for running multiple fuel models with the same weather data.

If UPDATE is to be changed from its previous setting, change it **first**, before entering any other data. It is placed first in the input list for convenience. Notice that when UPDATE was set to Yes in day 2, the updatable items (yesterday's values) were not asked for. In addition, if the station parameters (items 22-26) do not change, input can be terminated by pressing ENDLINE when a fuel model is requested.

If your daily calculations get "off track" because of some prior erroneous input, you can restart the calculations from the most recent date for which you have recorded correct results. Follow the procedures described previously for starting at the beginning of a session, but be aware that the GREEN DAYS value should be appropriate for the month and day of the midseason startup.

OPERATION OF THE "DIRECT" MODULE

The purpose of the DIRECT module is to permit calculation of NFDR indexes and components from direct entry of fuel moisture rather than moisture values calculated from weather inputs. This provides a "gaming" flexibility for use in research, training, or planning.

Example "DIRECT" Runs

Exhibit 4 gives an example of two runs to illustrate use of the DIRECT module to obtain both a full output list and an optional shortened output list. Select the DIRECT module, enter the data, and run each example in turn. Only outputs 1-4 and 8 are obtained in the second run in exhibit 4 because both the Man-caused Risk and the Lightning Risk Scaling Factor were entered as zero. Zero does not need to be entered for either MCR or LRSF more than once. Enter these values again only if you want to change them; otherwise, terminate input by pressing ENDLINE when these inputs are requested.

In DIRECT, state of weather and temperature **do not** affect the fuel moistures; however, they do affect the Ignition Component and the outputs which are in turn affected by the Ignition Component.

Exhibit 4.—Example DIRECT module inputs and outputs for two typical runs.

SAMPLE NFDR DIRECT OPTION DATA FORM

Name _____ Date _____ Sheet _____ of _____

INPUTS

Line Number	Mnemonic	Item	Range	Value		
1	FUEL MODEL	Fuel model name	(A-Z)	S	H	
2	1 HRFM	1-hour fuel moisture	(2-50%)	7	9	
3	10 HRFM	10-hour fuel moisture	(2-50%)	8	10	
4	100 HRFM	100-hour fuel moisture	(2-50%)	10	11	
5	1000 HRFM	1000-hour fuel moisture	(2-50%)	12	13	
6	WOOD FM	Live woody fuel moisture	(30-200%)	95	110	
7	HERB FM	Live herbaceous fuel moisture	(2-250%)	90	100	
8	WINDSPEED	20-foot windspeed	(0-60 mi/h)	5	10	
9	SLOPE CLASS	Slope class	(1-5)	1	3	
10	STATE WTHR	State of weather	(0-9)	0	0	
11	TEMP	Temperature	(0-120°F)	80	85	
12	MAN RISK	[1]Man-caused risk	(0-100)	10	0	
13	LRSF	[2]Lightning risk scaling factor	(0-1)	0.8	0	
14	Y-LGT OCC	Yesterday's lightning occurrence	(0-100)	24	–	
15	LGT ACT LVL	Lightning activity level	(1-6)	2	–	

OUTPUTS

	Indexes and Components				
1	SC	Spread Component	2	3	
2	ERC	Energy Release Component	14	20	
3	BI	Burning Index	15	18	
4	IC	Ignition Component	16	18	
5	MCOI	[1]Man-Caused Occurrence Index	2	–	
6	LRISK	[2]Lightning Risk	10	–	
7	LOI	[2]Lightning Occurrence Index	9	–	
8	FLI	Fire Load Index	13	13	

[1]If man-caused risk is 0, man-caused occurrence index will not be output.
[2]If the lightning risk scaling factor is 0, lightning risk and lightning occurrence index will not be output.
If both man-caused risk and lightning risk scaling factor are zero, man-caused occurrence index, lightning risk, and lightning occurrence index will not be output.

COMMUNICATION BETWEEN WEATHER AND DIRECT

All the inputs except "yesterday's" inputs are common to both WEATHER and DIRECT, that is, they are "known" to both modules. These are: FUEL MODEL, 1-, 10-, 100-, 1000-HR, HERB and WOOD moistures, wind, slope class, state of weather, temperature, man-caused risk, lightning risk scaling factor, and lightning occurrence level. Thus, if any of these values are set in DIRECT, they will also be set in WEATHER and vice versa. This feature permits the use of WEATHER to calculate fuel moistures for DIRECT. Then DIRECT can be used to determine how the NFDR indexes and components change as other DIRECT inputs are varied. If you were to then switch back to WEATHER and run it without inputting a new set of weather data, the values of the most recent DIRECT run would be used by WEATHER. But normally you would Input new weather data before running the WEATHER module. The new weather input, along with the fact that none of the "yesterday's" values are changed by DIRECT, assure correct output for the next weather run.

REFERENCES

Burgan, Robert E. Fire danger/fire behavior computations with the Texas Instruments TI-59 calculator: user's manual. General Technical Report INT-61. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1979. 25 p.

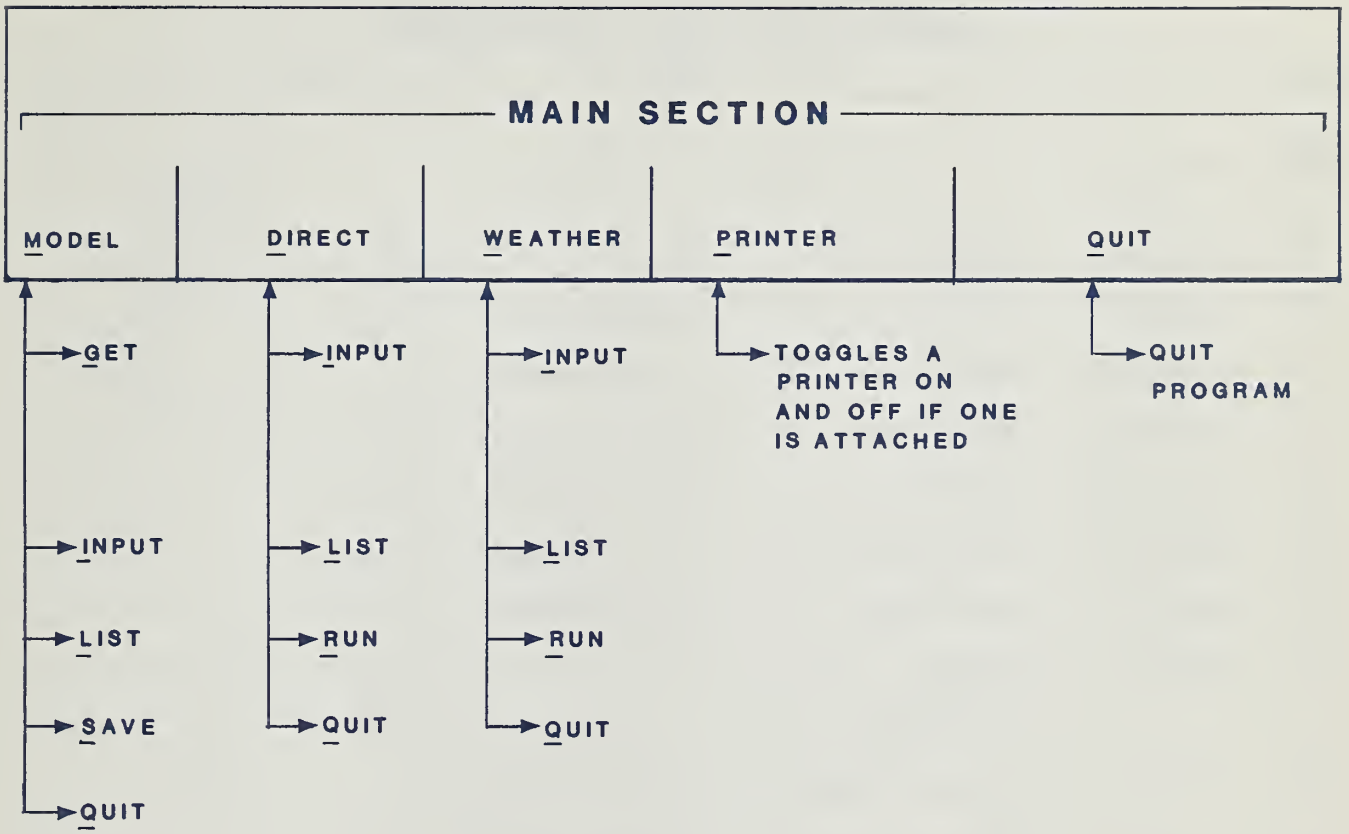
Burgan, Robert E.; Rothermel, Richard C. BEHAVE: fire behavior prediction and fuel modeling system—FUEL subsystem. General Technical Report INT-167. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1984. 126 p.

Deeming, John E.; Burgan, Robert E.; Cohen, Jack D. The National Fire-Danger Rating System—1978. General Technical Report INT-39. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1977. 63 p.

Helfman, Robert S.; Straub, Robert J.; Deeming, John E. User's guide to AFFIRMS: time-share computerized processing for fire danger rating. General Technical Report INT-82. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1980. 150 p.

Susott, Ronald A.; Burgan, Robert E. Fire behavior computations with the Hewlett-Packard HP-71B calculator. General Technical Report INT-202. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station; 1986.

APPENDIX A: NFDR PROGRAM STRUCTURE AND KEYWORD LIST



APPENDIX B: SAMPLE DATA FORMS

SAMPLE USER FUEL MODEL FORM

Name _____ Date _____ Sheet _____ of _____

Line Number	Mnemonic	Item	Range	Value
1	FUEL MODEL	Fuel model name	(V-Z)	
2	1 HR LOAD	1-hour load	(0.01-30 tons/acre)	
3	10 HR LOAD	10-hour load	(0.0-30 tons/acre)	
4	100 HR LOAD	100-hour load	(0.0-30 tons/acre)	
5	1000 HR LOAD	1000-hr load	(0.0-30 tons/acre)	
6	WOOD LOAD	Live woody load	(0.0-30 tons/acre)	
7	HERB LOAD	Live herb load	(0.0-30 tons/acre)	
8	HERB TYPE	Herb type 1 = annual 2 = perennial	(1-2)	
9	1 HR S/V	1 hr surface/volume ratio	(1200-3500 ft^2/ft^3)	
10	WOOD S/V	Live woody surface/ volume ratio	(1200-3500 ft^2/ft^3)	
11	HERB S/V	Live herb surface/ volume ratio	(1200-3500 ft^2/ft^3)	
12	HEAT	Heat content	(7000-12000 Btu/lb)	
13	MOIS EXT	Dead fuel moisture of extinction	(10-50%)	
14	DEPTH	Fuel bed depth	(0.1-10 ft)	
15	WIND FACTOR	Wind adjustment factor	(0-1)	
16	SCM	[1]Maximum probable spread component	(0-1000)	

[1]SCM is automatically calculated when the fuel model is saved. Enter here for reference when it is displayed.

(con.)

APPENDIX B: (Con.)

SAMPLE NFDR WEATHER OPTION DATA FORM

Name _____ Date _____ Sheet _____ of _____

INPUTS

Line Number	Mnemonic	Item	Range	Value		
1	UPDATE	Update	(Y/N)			
2	MONTH	Month	(1-12)			
3	DAY	Day	(1-31)			
4	GREEN DAYS	Green days	(0-366)			
5	STATE WTHR	State of weather	(0-9)			
6	TEMP	Dry bulb temperature	(0-120°F)			
7	RH	Relative humidity	(0-100%)			
8	10 HRFM	[1]10-hour fuel moisture	(2-50%)			
9	WINDSPEED	20-foot windspeed	(0-60 mi/h)			
10	MAX TEMP	Maximum temperature	(0-120°F)			
11	MIN TEMP	Minimum temperature	(0-120°F)			
12	MAX RH	Maximum relative humidity	(0-100%)			
13	MIN RH	Minimum relative humidity	(0-100%)			
14	PRECIP DUR	Precipitation duration	(0-24 hours)			
15	Y-100 HRFM	Yesterday's 100-hour moisture	(2-50%)			
16	Y-1000 HRFM	Yesterday's 1000-hour moisture	(2-50%)			
17	Y-X1000 HRFM	Yesterday's X1000 moisture	(2-50%)			
18	Y-HERB FM	Yesterday's herb moisture	(2-50%)			
19	MAN RISK	[2]Man-caused risk	(0-100)			
20	LGT ACT LVL	Lightning activity level	(1-6)			
21	Y-LGT OCC	Yesterday's lightning occurrence	(0-100)			
22	FUEL MODEL	Fuel model name	(A-Z)			
23	LATITUDE	Latitude	(−67 to 67°)			
24	SLOPE CLASS	Slope class	(1-5)			
25	CLIM CLASS	Climate class	(1-4)			
26	LRSF	[3]Lightning risk scaling factor	(0-1)			

(con.)

SAMPLE NFDR WEATHER OPTION DATA FORM (Con.)

Name _____ Date _____ Sheet _____ of _____

OUTPUTS

Line Number	Mnemonic	Item	Units	Value		
	Indexes and Components					
1	SC	Spread Component		_____	_____	_____
2	ERC	Energy Release Component		_____	_____	_____
3	BI	Burning Index		_____	_____	_____
4	IC	Ignition Component		_____	_____	_____
5	MCOI	[2]Man-Caused Occurrence Index		_____	_____	_____
6	LRISK	[3]Lightning Risk		_____	_____	_____
7	LOI	[3]Lightning Occurrence Index		_____	_____	_____
8	FLI	Fire Load Index		_____	_____	_____
	Moistures					
9	1 HRFM	1-hour fuel moisture	(pct)	_____	_____	_____
10	10 HRFM	10-hour fuel moisture	(pct)	_____	_____	_____
11	100 HRFM	100-hour fuel moisture	(pct)	_____	_____	_____
12	1000 HRFM	1000-hour fuel moisture	(pct)	_____	_____	_____
13	X1000 HRFM	X1000 fuel moisture	(pct)	_____	_____	_____
14	WOOD FM	Live woody fuel moisture	(pct)	_____	_____	_____
15	HERB FM	Live herbaceous fuel moisture	(pct)	_____	_____	_____

[1]If a 10 H moisture is input, that same value will be output, except that it will never be less than 2. If the 10 H moisture is entered as 2, a calculated value will appear in the output list.
[2]If man-caused risk is 0, man-caused occurrence index will not be output.
[3]If the lightning risk scaling factor is 0, lightning risk and lightning occurrence index will not be output.
If both man-caused risk and lightning risk scaling factor are zero, man-caused occurrence index, lightning risk, and lightning occurrence index will not be output.
[4]Updatable items not requested because UPDATE is set to Yes.

APPENDIX B: (Con.)

SAMPLE NFDR DIRECT OPTION DATA FORM

Name _____ Date _____ Sheet _____ of _____

INPUTS

Line Number	Mnemonic	Item	Range	Value		
1	FUEL MODEL	Fuel model name	(A-Z)	_____	_____	_____
2	1 HRFM	1-hour fuel moisture	(2-50%)	_____	_____	_____
3	10 HRFM	10-hour fuel moisture	(2-50%)	_____	_____	_____
4	100 HRFM	100-hour fuel moisture	(2-50%)	_____	_____	_____
5	1000 HRFM	1000-hour fuel moisture	(2-50%)	_____	_____	_____
6	WOOD FM	Live woody fuel moisture	(30-200%)	_____	_____	_____
7	HERB FM	Live herbaceous fuel moisture	(2-250%)	_____	_____	_____
8	WINDSPEED	20-foot windspeed	(0-60 mi/h)	_____	_____	_____
9	SLOPE CLASS	Slope class	(1-5)	_____	_____	_____
10	STATE WTHR	State of weather	(0-9)	_____	_____	_____
11	TEMP	Temperature	(0-120°F)	_____	_____	_____
12	MAN RISK	[1]Man-caused risk	(0-100)	_____	_____	_____
13	LRSF	[2]Lightning risk scaling factor	(0-1)	_____	_____	_____
14	Y-LGT OCC	Yesterday's lightning occurrence	(0-100)	_____	_____	_____
15	LGT ACT LVL	Lightning activity level	(1-6)	_____	_____	_____

OUTPUTS

	Indexes and Components				
1	SC	Spread Component	_____	_____	_____
2	ERC	Energy Release Component	_____	_____	_____
3	BI	Burning Index	_____	_____	_____
4	IC	Ignition Component	_____	_____	_____
5	MCOI	[1]Man-Caused Occurrence Index	_____	_____	_____
6	LRISK	[2]Lightning Risk	_____	_____	_____
7	LOI	[2]Lightning Occurrence Index	_____	_____	_____
8	FLI	Fire Load Index	_____	_____	_____

[1]If man-caused risk is 0, man-caused occurrence index will not be output.
[2]If the lightning risk scaling factor is 0, lightning risk and lightning occurrence index will not be output.
If both man-caused risk and lightning risk scaling factor are zero, man-caused occurrence index, lightning risk, and lightning occurrence index will not be output.

APPENDIX C: NFDR FUEL MODEL DESCRIPTIONS

The descriptions of the 20 NFDR fuel models are given in the following tabulation:

Model	Loads (T/A)						S/V (ft^2/ft^3)			Heat Content *(Btu/lb)*	Mois Ext *(%)*	Depth *(ft)*	Wind Factor	SCM	Herb type
	1 HR	10 HR	100 HR	1000 HR	Herb	Wood	1 HR	Herb	Wood						
A	0.20	0.00	0.00	0.00	0.30	0.00	3,000	3,000	1,200	8,000	15	0.80	0.6	301	A
B	3.50	4.00	.50	.00	.00	11.50	700	1,200	1,250	9,500	15	4.50	.5	58	—
C	.40	1.00	.00	.00	.80	.50	2,000	2,500	1,500	8,000	20	.75	.4	32	P
D	2.00	1.00	.00	.00	.75	3.00	1,250	1,500	1,500	9,000	30	2.00	.4	68	P
E	1.50	.50	.25	.00	.50	.50	2,000	2,000	1,500	8,000	25	.40	.4	25	P
F	2.50	2.00	1.50	.00	.00	9.00	700	1,200	1,250	9,500	15	4.50	.5	24	—
G	2.50	2.00	5.00	12.00	.50	.50	2,000	2,000	1,500	8,000	25	1.00	.4	30	P
H	1.50	1.00	2.00	2.00	.50	.50	2,000	2,000	1,500	8,000	20	.30	.4	8	P
I	12.00	12.00	10.00	12.00	.00	.00	1,500	1,200	1,200	8,000	25	2.00	.5	65	—
J	7.00	7.00	6.00	5.50	.00	.00	1,500	1,200	1,200	8,000	25	1.30	.5	44	—
K	2.50	2.50	2.00	2.50	.00	.00	1,500	1,200	1,200	8,000	25	.60	.5	23	—
L	.25	.00	.00	.00	.50	.00	2,000	2,000	1,200	8,000	15	1.00	.6	178	P
N	1.50	1.50	.00	.00	.00	2.00	1,600	1,200	1,500	8,700	25	3.00	.6	167	—
O	2.00	3.00	3.00	2.00	.00	7.00	1,500	1,500	1,500	9,000	30	4.00	.5	99	—
P	1.00	1.00	.50	.00	.50	.50	1,750	2,000	1,500	8,000	30	.40	.4	14	P
Q	2.00	2.50	2.00	1.00	.50	4.00	1,500	1,500	1,200	8,000	25	3.00	.4	59	P
R	.50	.50	.50	.00	.50	.50	1,500	2,000	1,500	8,000	25	.25	.4	6	P
S	.50	.50	.50	.50	.50	.50	1,500	1,500	1,200	8,000	25	.40	.6	17	P
T	1.00	.50	.00	.00	.50	2.50	2,500	2,000	1,500	8,000	15	1.25	.6	96	P
U	1.50	1.50	1.00	.00	.50	.50	1,750	2,000	1,500	8,000	20	1.50	.4	16	P

[1]A = Annual, P = Perennial.

The surface-area-to-volume ratios (S/V) for the 10-, 100-, and 1,000-H fuels are 109, 30, and 8, respectively. These values are not included as part of the model inputs because they are automatically assigned within the program. Neither do they need to be entered for user models. It is assumed that **all** models will have a 1-HR load and S/V ratio.

Mois Ext is the dead fuel moisture of extinction, in percent.

Fuel bed depth is indicated in feet.

Wind Factor is the adjustment factor by which the 20 mi/h windspeed is multiplied to get the midflame windspeed.

SCM is the maximum probable spread component. It is automatically calculated for and stored with any user model you save.

A/P indicates whether the model is annual or perennial. Because this condition is set for the NFDR models, it can be changed only by getting an NFDR model, changing herb type (input 8) and saving the model as a user model.

U. S. GOVERNMENT PRINTING OFFICE: 1986—676-039 20.038 REGION NO. 8

Burgan, Robert E.; Susott, Ronald A. Fire danger computations with the Hewlett-Packard HP-71B calculator. General Technical Report INT-199. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station; 1986. 16 p.

Describes how to compute indexes and components for the 1978 National Fire-Danger Rating System using the Hewlett-Packard 71B handheld calculator and custom memory. Predicting fire behavior with the HP-71B is described in a separate publication, "Fire Behavior Computations with the Hewlett-Packard HP-71B Calculator," by Ronald A. Susott and Robert E. Burgan, to be issued at a later date.

KEYWORDS: fire danger computations, National Fire-Danger Rating System, portable calculation aid

INTERMOUNTAIN RESEARCH STATION

The Intermountain Research Station provides scientific knowledge and technology to improve management, protection, and use of the forests and rangelands of the Intermountain West. Research is designed to meet the needs of National Forest managers, Federal and State agencies, industry, academic institutions, public and private organizations, and individuals. Results of research are made available through publications, symposia, workshops, training sessions, and personal contacts.

The Intermountain Research Station territory includes Montana, Idaho, Utah, Nevada, and western Wyoming. Eighty-five percent of the lands in the Station area, about 231 million acres, are classified as forest or rangeland. They include grasslands, deserts, shrublands, alpine areas, and forests. They provide fiber for forest industries, minerals and fossil fuels for energy and industrial development, water for domestic and industrial consumption, forage for livestock and wildlife, and recreation opportunities for millions of visitors.

Several Station units conduct research in additional western States, or have missions that are national or international in scope.

Station laboratories are located in:

Boise, Idaho

Bozeman, Montana (in cooperation with Montana State University)

Logan, Utah (in cooperation with Utah State University)

Missoula, Montana (in cooperation with the University of Montana)

Moscow, Idaho (in cooperation with the University of Idaho)

Ogden, Utah

Provo, Utah (in cooperation with Brigham Young University)

Reno, Nevada (in cooperation with the University of Nevada)